Back on Track
Injury Prevention & Management

Visons Conference

July 14-15 2016, Twin Waters Resort, Maroochydore

Presenter

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Since establishing Back On Track in 2005, Leanne has supported the needs of SMEs, large corporations and government to implement effective, evidence-based occupational health initiatives. Leanne is passionate about health and the importance of evidence to support workplace interventions. She has seen the trends come and go and scrutinises new products, designs and training for efficacy before offering them to industry.

Leanne will discern the literature to help OH&S practitioners and managers identify effective ergonomic tools to promote occupational health and bridge the gap between research and practice.

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Musculoskeletal discomfort among drivers: How to establish the presence (or absence) of occupational risk and what to do about it.

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Visions Conference, Maroochydore
15 July 2016

Abstract

Reports of musculoskeletal discomfort are prevalent among professional drivers – truck drivers, machine operators, couriers etc – and the risk of low back pain is known to be higher than average. Drivers generally experience several musculoskeletal disorder risk factors including exposure to whole-body vibration, sedentary work and awkward sitting postures. Underlying these physical risk exposures may be industrial issues, psychosocial factors and personal preferences which can motivate workers to raise concerns about particular work vehicles. This multifactorial problem can create significant challenges for safety and health professionals when trying to assess risk, manage injury and provide solutions. This discussion details:

- Ergonomic principles of vehicle seating;
- Common problems encountered with vehicle ergonomics including accommodating taller, broader and heavier workers;
- Whole-body vibration exposure, static sitting and poor posture and their relative contribution to low back pain; and
- Practical solutions for the prevention and management of musculoskeletal discomfort in drivers.

Case examples from industry are used to illustrate common problems, and practical solutions are offered to assist safety and health professionals to manage the ergonomic risk factors of occupational driving.

Introduction

Musculoskeletal discomfort, and in particular low back pain (LBP), is prevalent among professional drivers such as truck drivers, machine operators, couriers, taxi drivers and many others. It is now widely acknowledged that back pain is a complex disorder with numerous contributing factors, including physical, biological and psychosocial factors, as well as genetic and environmental interactions[1], and these risk factors may exist within the individual and in the workplace.

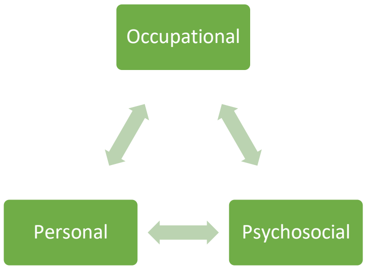


Fig.1 Multiple risk factors interactions are implicated in the development of musculoskeletal disorders.

Determining which of these factors needs to be addressed in the management of a worker with low back pain can be incredibly difficult. Establishing the presence or absence of vehicle-related physical risk factors such as poor ergonomics, is a relatively simple and objective process compared with the complexity of addressing psychosocial risk factors. This paper focusses on the occupational environment and provides safety and health professionals with awareness of the factors that may be implicated in back pain reports among drivers and what support or ergonomic improvements may be offered.

The prevalence of LBP among industrial drivers is considered to be higher than the population average. [2 3 4 5] While there is ample evidence to show an association between industrial driving and back pain, it is difficult to establish causation. What is it about driving that increases the likelihood of developing LBP?

Causative factors implicated in the development of musculoskeletal disorders are widely known to include exposure to:

- Repetitive or sustained force, [6]
- High or sudden force,
- Repetitive movement,
- Sustained or awkward posture,
- Vibration.

Industrial drivers may experience several risk factors including significant duration of exposure to sustained sitting, awkward sitting postures and whole-body vibration (WBV). [7] They may also experience exposure to risk factors outside of their driving time, particularly with materials handling[8] as might be the case for a courier driver or forklift operator.

The multifactorial aetiology of LBP makes it difficult for researchers to control the many variables. It is widely understood that psychosocial risk factors, both workplace and personal, are important in LBP. Despite significant improvements in workplace risk factors, such as reduced manual lifting, back pain reporting has not decreased.[9] Attempts to establish the relative contribution of each of the risk factor categories continue, and findings to date suggest contributions from each listed in the Table 1.[10]

Personal risk factors	Psychosocial risk factors	Occupational risk factors
Age Genetics Smoking BMI Alcohol consumption Family history Physical activity	Perceived stress Decision latitude Job stress Job security Job satisfaction Job demands Social relationships Organisational level	Physical load Bending Twisting Force Repetition Lifting Vibration Posture

Table 1 Govindu et al 2014 review of literature shows association between LBP and a range of personal, psychosocial and occupational risk factors.

Returning focus to occupational risk factors, attempts continue to be made and further research is still needed to establish the relative contribution to LBP of sustained sitting, awkward postures and WBV during driving. It is certainly known that each of these is a risk factor in its own right.

Establishing the presence or absence of risk factors in driving is essential in determining whether there is an occupational risk, and if so, to ensure appropriate risk controls are implemented. So, to establish the presence or absence of occupational risk for industrial drivers, three questions arise:

1. What constitutes an awkward driving posture?
2. How much WBV is too much?
3. What duration of sustained sitting for driving is too much?

These three questions are explored. A review of the literature establishes current knowledge and industry examples are used to illustrate solutions.

What constitutes an awkward driving posture?

Let's first consider what constitutes a comfortable driving posture, or more specifically, what is the optimal seated position? This is a question that has been debated by physiotherapists and biomechanists for decades. What is comfortable for one person may be uncomfortable for another. For instance, use of a lumbar cushion reduces back pain for some but may increase back pain for others. It *is* known that sitting is associated with greater lumbar flexion than standing[11 12] and is associated with higher levels of paraspinal muscle activity and with increased load on the lumbar discs. These mechanical forces are considered to be the underlying reason for increased reports of low back pain in sitting[13].

In recent times, there has been increased emphasis on adopting neutral spinal postures and to avoid potentially harmful end-range flexion or extension and to facilitate activation of trunk stabilising muscles.[14 15 16] In 2012, O'Sullivan asked 295 physiotherapists in Perth[17] what, in their opinion, constitutes optimal sitting posture. From 9 images in Fig.2, physiotherapists overwhelmingly chose postures 5 and 9, both examples of a neutral posture, with one involving slightly more forward lean and hip flexion than the other.

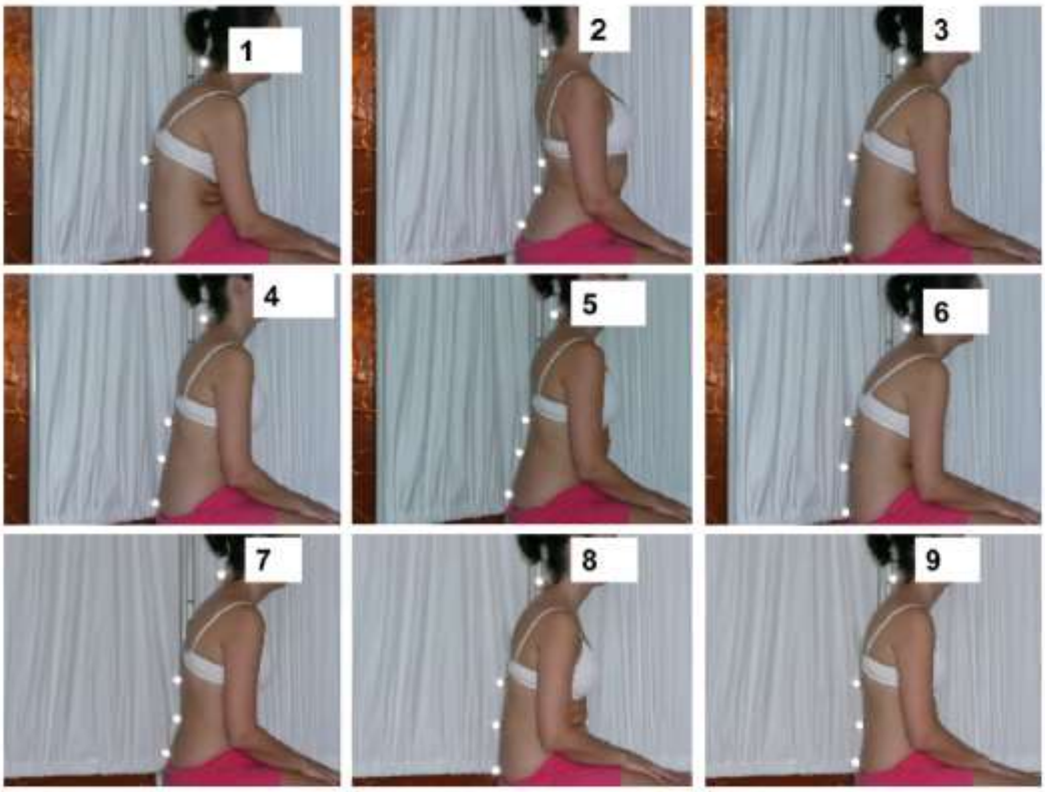


Fig.2 O'Sullivan et al' 1999 asked physiotherapist which was the optimal sitting posture.

What we can see from this is that physiotherapists encourage a neutral posture in which the lumbar lordosis is maintained. A review of sitting biomechanics in 1999[18] is the most extensive summary of research on the topic. It was commissioned by an automotive engineering company in the USA in response to a void of information in the literature. It tends to confirm what many of us experience, that a reclined supported posture is most preferred. This review confirmed previous findings and elaborated on the mechanical loading experienced in sitting. As depicted in Fig.3, sitting causes:

- the pelvis to rotate backward,
- reduced lumbar lordosis,
- reduced hip angle and knee angle and
- increased muscle effort and disc pressure.

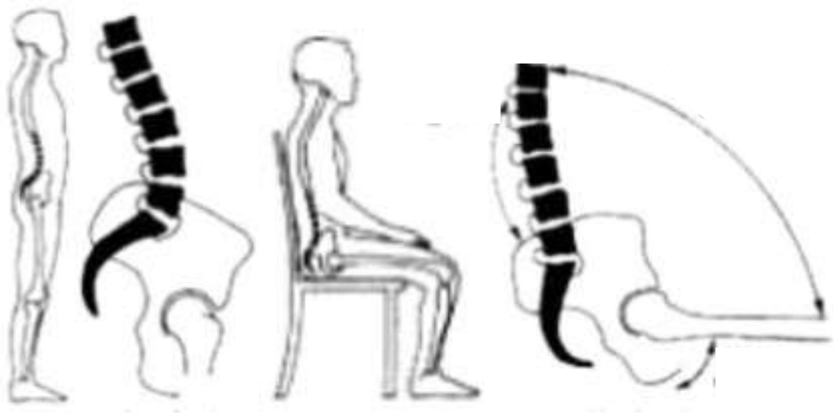


Fig. 3 Sitting rotates the pelvis backward, reduces the lumbar lordosis and reduces the hip angle.

Many people are familiar with Nachemson's 1965 study in which sitting is shown to involve greater spinal loading than standing. Andersson's 1974 study took this further and showed the loading patterns of different sitting postures[19]. Figure 4 clearly shows that the greater the posterior tilt of the pelvis, the greater the spinal loading. The greater the forward lean, the greater the spinal loading.

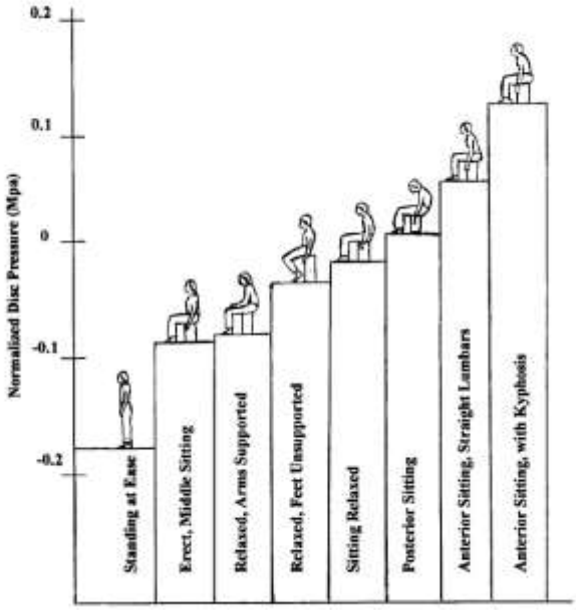


Fig.4 Andersson et al's 1974 disc-pressure findings in unsupported sitting.

The degree to which this happens is dependent on the seat-back angle, seat-bottom angle, foam density, seat height above the floor, presence of lumbar support and arm rests. In 1953, Keegan[20] aptly identified a series of optimal seating features. The sitting biomechanics review of 1999 confirmed and refined much of what was already known in 1953. Optimal sitting characteristics include:

1. Trunk-thigh angle, or hip angle, of 110-130° is associated with neutral anterior and posterior thigh muscle tension and neutral lumbar lordosis. Hip angle of 110° is preferred over broader angles to reduce cervical spine loading.
2. Seat-bottom between 0° (flat) and 10° posteriorly inclined.

3. Presence of lumbar support, ideally around 5cm in depth.
4. Seat length to suit thigh length.
5. Convex thoracic support with height to the scapulae and reclined around 105°.

Harrison et al continued their literature review in Part II[21] and focussed their attention on the specific biomechanics of vehicle seating. Their review found:

1. Preferred hip angle of 110°. If the seat bottom is angled 10° posteriorly then the seat back needs to be 120° to the floor.
2. In consideration of the large cervical flexion angle, the inclination should perhaps be reduced to lessen the cervical load.
3. Disc loading is reduced by arm rests but they must be adjustable in height and angle. Aaras studied arm position in factory and office workers and found an optimum position of shoulder flexion less than 15° and abduction of less than 10°.[22] Door arm rests are not adequate as they are not adjustable and are usually too low.
4. Back rest or seat length adjustability to suit a range of leg lengths.
5. Head rest adjustability vertically and horizontally. Discomfort is associated with a head rest that pushes the head forward. The headrest should have a convex surface. Headrest height should extend beyond the driver's head.
6. Pulsating lumbar support. Further research is needed but the authors suggest that a pulsating pneumatic lumbar support offering continuous passive motion may offer benefits.
7. Crash protection is a complex issue which can at times compete with ergonomic and comfort specifications.

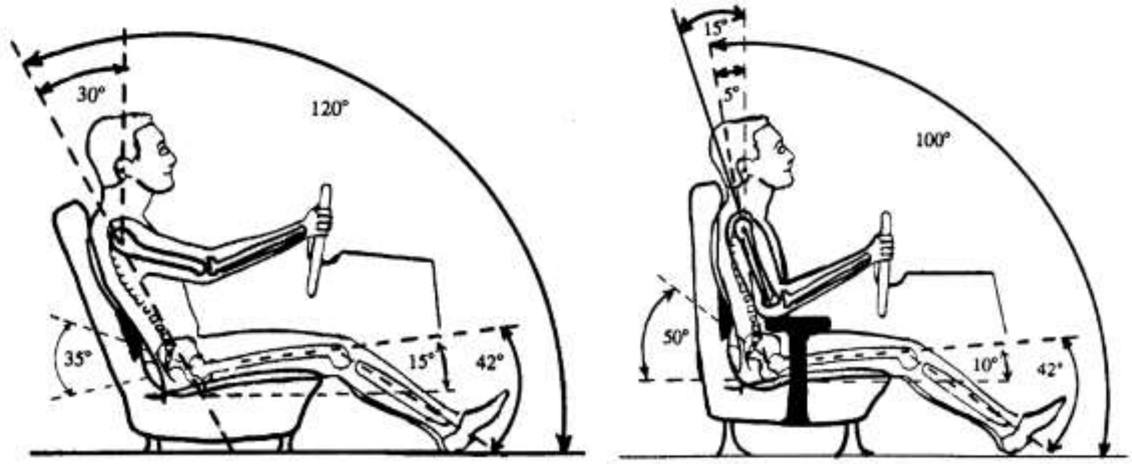


Fig 5. Harrison et al 2000 suggested a preferred backrest angle of 120° however this resulted in awkward neck flexion of 30°. A compromised back rest angle of 100° was therefore suggested.

De Looze et al (2003) studied driver sitting comfort and found that favourable distribution of pressure between the ischial tuberosities and the back is strongly linked to perceived driver comfort.[23] Seats with the most forward flexion were always associated with the most discomfort. Presence of lumbar support was strongly linked with comfort.

Practical application

Ergonomic assessment of vehicle seating is an important tool in establishing whether or not a neutral posture is promoted. Ergonomics assessment on sedans, SUVs, trucks, and mobile plant have yielded interesting and often surprising results. Some anecdotal observations are included herein.

Fleet vehicle review

An ergonomic review of fleet options for a Queensland employer included Hyundai i30, Citroen Berlingo, Toyota Corolla, Volkswagon Caddy, Renault Kangoo and Fiat Doblo. For several years, this employer had included ergonomic assessment as part of any vehicle or machine procurement. Anthropometric data was used and included Department of Defence data to purposely influence norms toward the taller, broader and heavier male workers who were considered to reflect the working population of this employer.

Some of the pertinent findings included:

- The Volkswagon, Renault, Fiat and Citroen offered ample head clearance for even the tallest of male workers, while the Toyota would only *just* accommodate the 95th percentile. The Hyundai failed to accommodate male workers in the 95th percentile but would accommodate taller female workers.
- The van-style vehicles, Citroen, Volkswagon, Fiat and Renault offered the highest seat position while the Hyundai and Toyota offered the lowest seat positions. This influenced the spinal position of workers such that the hip angle was reduced in the lower seats with increased low back loading.
- Cargo barriers impeded the full range of seat movement forward-back and in back rest recline. This resulted in reduced hip angles and increased spinal loading.
- No vehicles offered lumbar support, adjustable or otherwise.
- Several vehicles had headrests that pushed the head forward into an awkward and uncomfortable position.

Whilst this author is not privy to manufacturers' build specifications, it seems likely that price and country of manufacture influence cabin ergonomics. For instance, Asian populations are on average smaller than Scandinavian populations and this seems to be reflected in the cabin and seating dimensions.

Truck review

An ergonomic review of 3 different trucks, Ivecco Acco, Hino FM2630 and Mack Metroliner, as part of vehicle procurement for a Queensland employer showed the following:

- The Iveco offered insufficient head room to accommodate taller workers.
- All vehicles offered adjustable height and depth of lumbar support.
- The Mack offered superior ergonomics of access and egress.
- Seat-dash clearance in the Hino did not accommodate taller workers.

In fact, the employer selected the Hino for its performance criteria and as a result of the ergonomic assessment the manufacturer was able to offer a modification in which the seat mounts were moved rearward and taller workers were accommodated safely and comfortably.

There are some noteworthy generalisations that can be made from many years of vehicle ergonomic assessments. Vehicle manufacturers may not be building to the populations sizes of today. People are taller, broader and heavier than in previous generations[24] and this seems to affect driving comfort for bigger workers. SUV-style seating seems to offer superior ergonomics compared with sedan-style seating. SUV seats are higher and tend to offer a more open hip angle which is associated with reduced low back loading and increased comfort.

Simple seating modifications can offer improved comfort for workers experiencing back pain. Where cabin clearances allow, add-on cushions can be used to increase seat depth or width, to widen shoulder support, to add lumbar support and to raise hips. Such modifications may reduce spinal loading and increase comfort. Custom seating modifications are available and pre-fabricated options also exist, such as lumbar cushions and wedge cushions to raise the hips. These are makeshift solutions that may be offered following an ergonomic assessment and are certainly worth trialling for workers who report discomfort with driving.

Employers are urged to undertake ergonomic review of vehicle seating, cabin clearances and vehicle access and egress as a routine part of procurement. Employers are also urged to engage a professional to conduct a vehicle ergonomic assessment when workers report pain or discomfort associated with driving.

How much WBV is too much?

It is now well established that exposure to WBV is a risk factor implicated in the development of low back disorders, such that WBV is identified in codes of practice and guidelines on the prevention of musculoskeletal disorders around the world. Burstrom et al's 2015[25] review revealed an approximately doubled risk of developing low back pain and a doubled risk of developing sciatica in workers exposed to WBV as depicted in Figure 6. This result is similar to results established in studies throughout the 1990s and 2000s.[26] [27] [28] The strength of the association is further established by the dose-response relationship. For instance, high WBV exposure helicopter pilots showed greater LBP and sciatica than lower exposure occupations, and this has been replicated in various studies.

Study name	Statistics for each study				
	Odds ratio	Lower limit	Upper limit	Z-Value	p-Value
Bovenzi et al. (2002)	1,23	0,98	1,54	1,80	0,07
Bongers et al. (1990)	9,00	4,38	18,49	5,98	< 0,01
Bovenzi & Zadini (1992)	2,57	1,52	4,35	3,52	< 0,01
Boshuizen et al. (1992)*	1,49	0,93	2,40	1,65	0,10
Bovenzi & Betta (1994)	2,39	1,57	3,65	4,04	< 0,01
Bovenzi et al. (2006)	2,81	1,31	6,03	2,65	0,01
Burdorf et al. (1993)*	1,75	1,03	2,97	2,07	0,04
	2,29	1,49	3,53	3,78	< 0,01
Johanning (1991)*	2,09	1,26	3,46	2,86	< 0,01
Boshuizen et al. (1990a)*	1,93	1,15	3,24	2,51	0,01
Magnusson et al. (1996)*	1,91	1,24	2,93	2,95	< 0,01
Okunribido et al. (2006)*	0,94	0,51	1,71	-0,21	0,83
Palmer et al. (2003)*	1,40	1,23	1,60	5,02	< 0,01
Johanning et al. (2006)	4,24	3,20	5,62	10,05	< 0,01
Hoy et al. (2005)*	3,52	1,04	11,83	2,03	0,04
Kumar et al. (2001)*	2,70	1,20	6,11	2,39	0,02
	2,06	1,37	3,09	3,46	< 0,01
	2,17	1,61	2,91	5,11	< 0,01

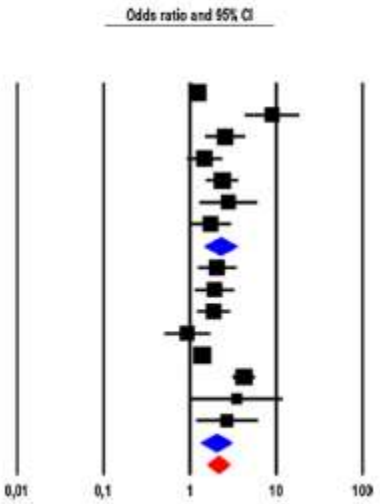


Fig.6 Burstrom et al 2015 shows odds ratios of developing LBP from WBV exposure.

Burstrom's review acknowledged that workers exposed to WBV often have exposure to prolonged sitting and awkward postures and that both of these factors can also cause LBP. Inclusion in the Burstrom review required that these confounding variables be controlled. So the association between WBV and LBP certainly holds, but the interaction between these variables remains unclear. Do the risk factors interact to reinforce each other's harmful effects?

VIBRISKS[29] is a European research project which sought to improve the understanding of the interaction of these variables. They established a dose-response relationship such that the higher the WBV exposure the higher the incidence of 12-month LBP, the pain intensity reports and LBP disability.

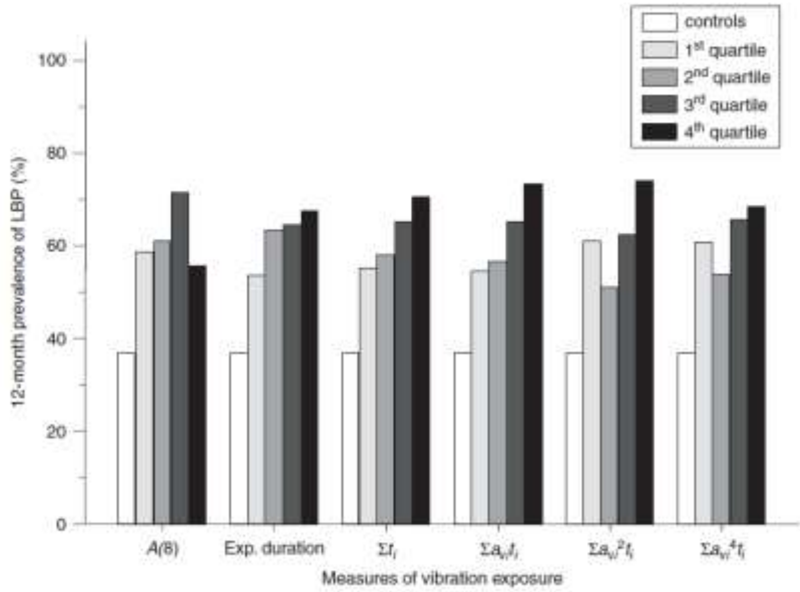


Fig.7 Bovenzi et al 2006 shows prevalence of LBP in the previous 12 months by quartiles of WBV exposure. WBV is expressed in terms of 8-hour energy equivalent frequency-rated magnitude, duration of exposure in years, and lifetime vibration dose estimates as a proportion of total driving time alone, or in combinations with vibration.

Bovenzi's review showed that WBV exposure was not associated with daily LBP incidence. Meaning, the effect of WBV exposure is a cumulative effect requiring months or years of exposure. However, the study established daily limits, under which the cumulative effects are less likely to cause harm. This study informed the EU Directive on mechanical vibration which set a daily exposure action value of $0.5 rms^{-2}$ above which employers must implement a program to reduce risk. Workers exposed above the action value are entitled to health surveillance.

Practical application

Until 2015, the only way to establish whether a vehicle or fleet of vehicles exposed workers to potentially harmful levels of WBV was to engage a specialist vibration engineer to conduct time-consuming and expensive testing; testing that was typically conducted sporadically and in an ad hoc manner. Burgess-Limerick and Lynas[30], with support from the Minerals Industry Safety & Health Centre, developed an iOS app to measure WBV exposure.

With the wide availability of smart phones equipped with an accelerometer, access is supported for frequent and cost-effective WBV measurement. The study used a fifth-generation iPod Touch which had some limitations on hardware on sampling rate and did not meet the ISO2631.1 instrumentation standards. However, extensive trialling and testing showed consistency of recording between the iPod and the more sophisticated instrumentation with 95% confidence.

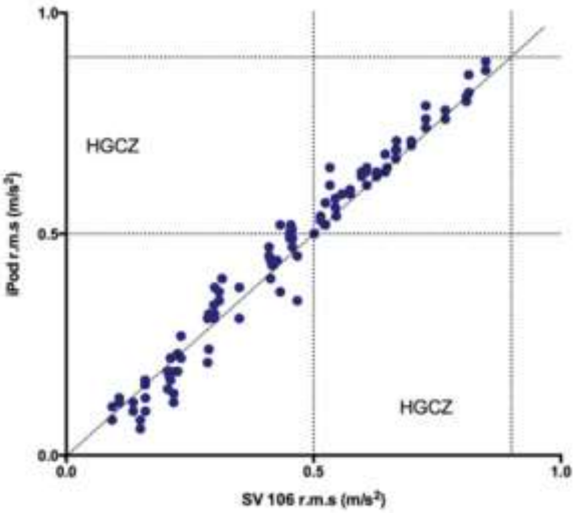


Fig.8 Burgess-Limerick et al 2015 shows 96 vertical WBV measures obtained using iOS application compared with simultaneous SV106 measures.

The app was developed and released for free to enable industry to accurately and simply monitor WBV exposure in workers. The WBV iOS application for iPhone and iPod touch is a practical, simple and reliable tool to investigate WBV in the workplace.

Sampling should occur for as long as practical, representing typical driving conditions. Factors which can influence WBV include driving surface, driving speed, tyre pressure, vehicle loading and seating suspension.

Figure 9 depicts the simple use of the iPhone or iPod under the left or right ischial tuberosity and the worker needs only to press start and recording begins. Once sampling is complete, the worker presses stop. The first and last 10 seconds of data are omitted from the results.

Fig.9 Burgess-Limerick 2014 iOS Application User Manual shows the positioning under the drivers ischial tuberosity on left or right.

ISO2631:1 describes two measurement and evaluation methods for health effects. These two measures are depicted in Fig.10. The RMS (root mean squared) axis measures frequency-rated vibration amplitude and the VDV (vibration dose value) axis measures a dose value that corresponds to the duration of exposure.

A graphical representation with 'traffic light' action levels is produced for WBV exposure where X represents forward-back movement, Y represents lateral movement and Z represents up-down movement.

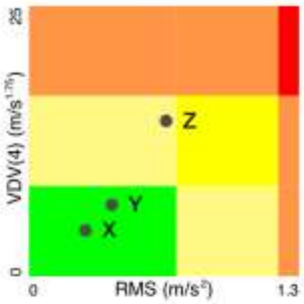
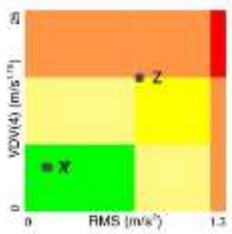
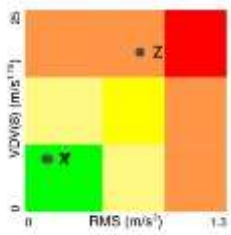
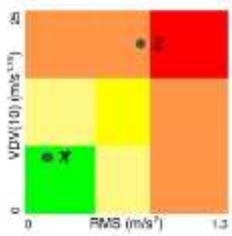
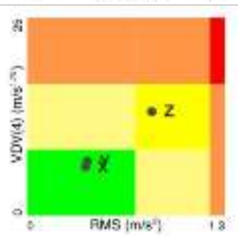


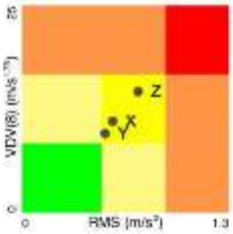
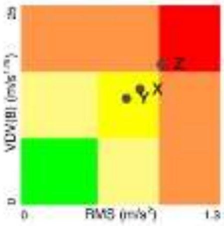
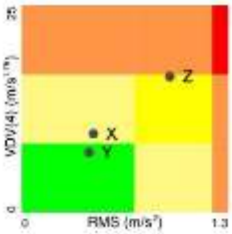
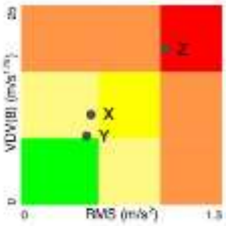
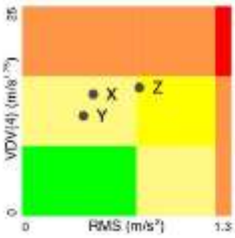
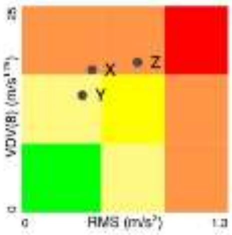
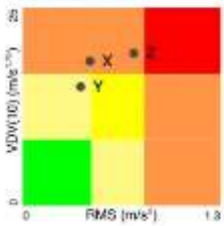
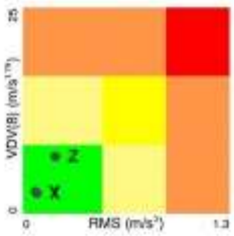
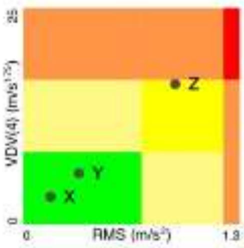
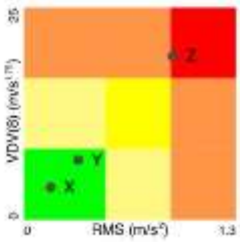
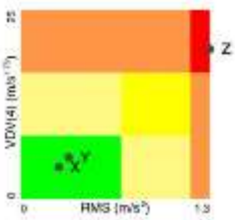
Fig.10 Example read of WBV exposure from iOS measurement.

ISO 2631:1 *1997 Mechanical vibration and shock - evaluation of human exposure to whole-body vibration* was adopted by Australia in 2001 as, *AS2670-2001 Evaluation of human exposure to whole-body vibration.* Action thresholds are based on ISO2361:1 which states that for exposures below the cautionary zone (RMS less than $0.5 m/s^2$ and VDV less than $9.2 m/s^{1.75}$) in green, health effects have *not* been clearly documented or objectively observed. In the yellow cautionary zone, there are potential health effects and in the orange and red zones, health effects are likely.

Findings from WBV assessment of different machines and vehicles is dependent on a multitude of factors including driving speed, terrain, tyre pressure, vehicle loading and more. Table 2 shows WBV measures from an audit conducted for a Queensland construction company across a range of machines. Graphs indicate exposure extrapolated for driving durations of 4 hours, 8 hours and 10 hours depending on the typical work requirements.

Table 2

Machine	4 hours	8 hours	10 hours
Excavator			
Forklift			

Machine	4 hours	8 hours	10 hours
Grader			
Mulcher			
Roller			
Trencher in rock			
Trencher in sand			
Truck on sealed road			
Truck on dirt road			

The findings from this audit resulted in the employer changing their procurement processes. There were noteworthy differences in quality of vibration dampening as well as cabin ergonomics between vehicle models. Interestingly, the more expensive machines were not necessarily associated with superior ergonomics. The employer arranged for task rotation among workers and planned for multi-skilling workers to further encourage rotation. Some machines underwent maintenance that improved the vibration dampening. Training was offered to workers in the use of seating adjustment and optimal ergonomics. Training was also offered by the in-house fitter mechanics and this involved teaching machine operators about how to improve machine settings and timing to reduce vibration. Finally, the employer also committed to include ergonomic assessment as part of future vehicle procurement.

Should action be required, the implementation of risk controls should be considered as part of the broader manual tasks risk assessment and the hierarchy of risk controls applies.

- Reducing or eliminating WBV at the source is preferable.
- Engineering options may be directed at vehicle suspension, seating suspension, vehicle maintenance, and procurement specifications.
- Administrative controls may include reduction of driving duration, training drivers in seating adjustments, setting of speed limits, and driving to conditions.

How long driving is too long?

It is well-established that movement is critical for health and well-being. Safe Work Australia commissioned a paper to evaluate occupational sitting and its emergent work health and safety issues.[31] Overall sedentary behaviour is strongly associated with health risks including cardiometabolic and musculoskeletal disorders. The health effects of *occupational* sitting, distinct from overall sedentary behaviour, is not yet fully understood. Preliminary findings suggest modest evidence to support an association with both cardiometabolic disorders and to a lesser extent, musculoskeletal disorders.

In Schodde v Comcare 2015, the applicant claimed that their lumbar disc degeneration was caused by prolonged sitting at work. The decision upheld that employment did not make a significant contribution to the degenerative condition. However, as further research emerges regarding the occupational contribution of excessive sitting, such decisions may be affected.

While the focus of this paper is on musculoskeletal disorders, the more serious morbidity and mortality associated with excessive sitting should not be ignored. Straker et al's review[31] indicated a 15% increased risk of dying with 8-11 hours of daily sitting and a 40% increase with more than 11 hours of sitting.

Industrial drivers are a relatively unexplored subgroup of sedentary workers. Most research at this time has focussed on office workers. A small Australian study by Gilson et al in 2016[32] looked at truck drivers and confirmed poor health and high sitting exposure. It is likely that some industrial drivers will have occupational sitting exposures which are indeed associated with increased risk of mortality.

It is also important to note much research has focussed on accident risk and fatigue with prolonged driving. Tucker's 2003 review[33] indicated that rest breaks are most effective when timed with periods of fatigue, however he went on to note that drivers are not always a good judge of their own fatigue. As such, scheduled or pre-planned rest breaks are recommended. NIOSH recommend a break of 15 minutes every 2 hours for computer users under moderate demands. This recommendation was provided in 1981 when workers typically experienced natural computer breaks due to other administrative tasks. Today, there is little need to leave a computer and it may be surmised that more frequent breaks are needed. Drivers are advised by the Queensland Department of Transport and Main Roads to take a break every 2 hours. The National Heavy Vehicle Register advises for an 8-hour driving shift, two 15-minute driving breaks. These recommendations are thought to be based on empirical evidence which suggest that performance declines and crash risk increases with sustained driving of more than 2-4 hours.

Returning focus to musculoskeletal disorders, duration of sitting is linked with fatigue and subsequent discomfort, which can result from one hour of driving[34]. The effect of driving seems to be cumulative with those driving for more than 20 hours per week being 6 times more likely to be absent from work due to LBP.[35] In addition to drive time, accumulating more than 40,000km per year has been linked with increased risk of musculoskeletal disorders.[36]

Practical application

The good news from Straker et al is that interrupting periods of sitting has shown positive effects on blood glucose regulation and on musculoskeletal comfort. Figure 11 shows the proportion of the different temporal patterns in which breaks in sustained sitting can be achieved and yield positive health effects. As little as 2-3 minutes of movement every 20-30 minutes has shown positive effects. In 2015, the UK Public Health commissioned a similar review to Straker's and derived some fairly specific guidelines. These recommend that for those occupations which are predominantly desk based, workers should aim to accumulate 2-4 hours of movement during their work day[37].

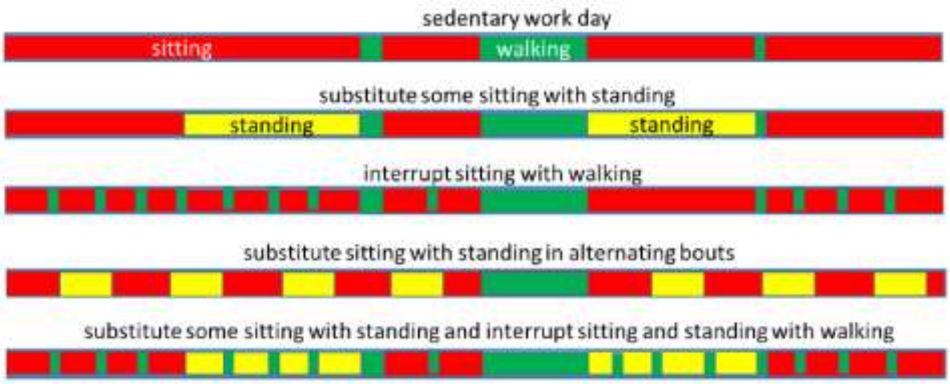


Fig.11 Straker et al 2016 illustrates how sedentary work can be reduced by substitution and interruption of sitting time.

Given that the postural constraints of drivers are even greater than office workers, this advice must surely be relevant and perhaps even underestimate the needs of drivers. A 3-minute break every 30 minutes is likely to be practical for some drivers. Operators of machines such as excavators, bobcats and forklifts are likely to be able to use natural work interruptions to take a standing or walking break. Courier drivers likely experience only short periods of sitting interspersed with standing and walking for deliveries. However, truck drivers and especially long haul drivers, may find implementing frequent breaks less practical.

Considering musculoskeletal discomfort, risk of metabolic disorders and increased mortality from excessive sitting, as well as increased accident risk with sustained driving, the overall guidelines for driver rest breaks support:

- a minimum schedule of pre-planned rest breaks,
- driver autonomy to take a rest break at times of perceived fatigue,
- more frequent short rest breaks rather than fewer, long rest breaks, and
- accumulation of 2-4 hours of movement and activity throughout the work day.

Although stretching is not considered a risk control, teaching sedentary workers a few targeted stretches, especially for the back, hips and legs, can be useful in managing discomfort and also gives workers a reason to exit their vehicle during downtime.

Employers are encouraged to consider ways in which work can be organised to provide workers with opportunities to move. For instance, multi-skilled workers may rotate between machine operation and manual tasks. Drivers may alternate between driving and loading vehicles. 'Manufactured' rest breaks are likely to be less practical and workers are likely to skip recommended breaks unless the break is purposeful.

Conclusions

Industrial drivers are exposed to risk factors which are known to be implicated in the development of musculoskeletal disorders. When safety and health professional seek to establish the source of a worker's discomfort or a work group's concerns about a particular vehicle, it can be difficult to establish the cause and source of the problem. We know that back pain is a complex disorder with numerous contributing factors, including physical, biological and psychosocial factors, as well as genetic and environmental interactions, and these risk factors may exist within the individual and in the workplace. Rather than be stymied by the problem's complexity, we can seek to establish the presence or absence of physical risk factors.

There is ample evidence to show that excessive exposure to sustained sitting, awkward postures and WBV is associated with musculoskeletal disorders, especially LBP. Safety and health professionals who seek to support workers and improve workplace safety need to consider and apply the guidance discussed herein. Identify and objectively assess exposure to non-optimal sitting postures, excessive sitting duration and excessive WBV, and then take remedial action.

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